

Applicant:
For:

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INTEGRATED ELECTROFLUIDIC SYSTEM AND METHOD

- 1 1. An integrated electrofluidic system comprising:
 - 2 an electronic control system mounted on a support platform;
 - 3 a microfluidic system embedded in said platform and having an input and
 - 4 an output and at least one electrofluidic component; and
 - 5 at least one electrical conductor carried by said platform for electrically
 - 6 interconnecting said electronic control system and said at least one electrofluidic
 - 7 component.
- 1 2. The integrated electrofluidic system of claim 1 in which said platform
- 2 includes a plurality of laminated layers forming said embedded microfluidic system.
- 1 3. The integrated electrofluidic system of claim 1 in which said platform
- 2 includes a polyimide material.
- 1 4. The integrated electrofluidic system of claim 1 in which said platform
- 2 includes KAPTON®.
- 1 5. The integrated electrofluidic system of claim 2 in which said layers are
- 2 laminated using a phenolic resin adhesive.
- 1 6. The integrated electrofluidic system of claim 5 in which said phenolic

2 resin adhesive is R/FLEX®.

1 7. The integrated electrofluidic system of claim 5 in which said phenolic
2 resin adhesive is etched to a thickness of 3 to 10 µm.

1 8. The integrated electrofluidic system of claim 5 in which said phenolic
2 resin adhesive is selectively removed from regions where bonding is undesirable between
3 said layers and/or between a said layer and said electrofluidic component and/or a
4 microfluidic component.

1 9. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a valve.

1 10. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a pump.

1 11. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a reservoir.

1 12. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a mixer.

1 13. The integrated electrofluidic system of claim 1 in which said microfluidic

2 system includes at least one channel.

1 14. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a filter.

1 15. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a dispenser.

1 16. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a reactor.

1 17. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a heater.

1 18. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a concentrator.

1 19. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a pressurizing device.

1 20. The integrated electrofluidic system of claim 1 in which said microfluidic
2 system includes a cooling device.

1 21. The integrated electrofluidic system of claim 1 further including a sensor
2 device integrated with said microfluidic system.

1 22. The integrated electrofluidic system of claim 21 in which said sensor
2 device is embedded in said platform.

1 23. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a flexure plate wave sensor.

1 24. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a photoelectric sensor device.

1 25. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes an optical sensor device.

1 26. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes an electrochemical sensor device.

1 27. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a temperature sensor device.

1 28. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a pressure sensor device.

1 29. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a flow sensor device.

1 30. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a viscosity sensor device.

1 31. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a mass sensor device.

1 32. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes a magnetic sensor device.

1 33. The integrated electrofluidic system of claim 21 in which said sensor
2 device includes an acoustic sensor device.

1 34. The integrated electrofluidic system of claim 1 further including a
2 dispenser device integrated with said microfluidic system.

1 35. The integrated electrofluidic system of claim 1 further including a heat
2 exchange device integrated with said microfluidic system.

1 36. The integrated electrofluidic system of claim 34 in which said dispenser
2 device includes a drug delivery device.

1 37. The integrated electrofluidic system of claim 1 further including a fuel cell
2 device integrated with said microfluidic device,

1 38. An integrated electrofluidic system comprising:
2 an electronic control system mounted on a support platform;
3 a microfluidic system embedded in said platform and having an input and
4 an output and at least one electrofluidic component;
5 at least one electrical conductor carried by said platform for electrically
6 interconnecting said electronic control system and said at least one electrofluidic
7 component; and
8 a sensor integrated with said electrofluidic system.

1 39. The integrated electrofluidic system of claim 38 in which said platform
2 includes a plurality of laminated layers forming said embedded microfluidic system.

1 40. An integrated electrofluidic system comprising:
2 an electronic control system mounted on a support platform;
3 a microfluidic system embedded in said platform and having an input and
4 an output and at least one electrofluidic component;
5 at least one electrical conductor carried by said platform for electrically
6 interconnecting said electronic control system and said at least one electrofluidic
7 component; and
8 a dispenser device integrated said electrofluidic system.

1 41. The integrated electrofluidic system of claim 40 in which said platform
2 includes a plurality of laminated layers forming said embedded microfluidic system.

1 42. The integrated electrofluidic system of claim 40 in which said dispensing
2 device dispenses fluid in the range of about 100 microliters to 100 picoliters.

1 43. The integrated electrofluidic system of claim 40 in which said dispensing
2 device dispenses fluid at a rate of about 0.1 to 100 microliters/min.

1 44. An integrated electrofluidic system comprising:
2 an electronic control system mounted on a support platform;
3 a microfluidic system embedded in said platform and having an input and
4 an output and at least one electrofluidic component;
5 at least one electrical conductor carried by said platform for electrically
6 interconnecting said electronic control system and said at least one electrofluidic
7 component; and
8 a heat exchange device integrated with said electrofluidic system.

1 45. The integrated electrofluidic system of claim 43 in which said platform
2 includes a plurality of laminated layers forming said embedded microfluidic system.

1 46. A method for manufacturing an integrated electrofluidic system, the
2 method comprising:

- 3 a) providing a substrate layer having an adhesive layer;
- 4 b) thinning said adhesive layer;
- 5 c) machining said adhesive layer and said substrate layer to create
6 features that define at least one microfluidic component and/or at least one electronic
7 component;
- 8 d) aligning said substrate layers;
- 9 e) laminating the layers to embed said microfluidic component and/or
10 said electronic component between said layers; and
- 11 f) repeating steps a) through e) for a predetermined number of layers
12 of said substrate and said adhesive layer.

1 47. The method of claim 46 in which said substrate layer is KAPTON®.

1 48. The method of claim 46 in which said adhesive layer is thinned by plasma
2 etching.

1 49. The method of claim 46 in which said adhesive layer and said substrate are
2 machined by applying an energy beam with a laser.

1 50. The method of claim 46 in which step a) further includes providing
2 additional microfluidic component and/or an electronic component to be embedded

3 between said layers.

1 51. The method of claim 46 further including the step of attaching additional
2 microfluidic components and/or electronic components to the top surface of said
3 laminated layers.

1 52. The method of claim 46 further including the step of applying a mask to
2 said adhesive layer to define removal of said adhesive and to further define said
3 microfluidic components.

1 53. The method of claim 46 in which step a) further includes providing
2 electrical pads and electrical leads for interconnecting said microfluidic components and
3 said electronic components.

1 54. The method of claim 46 further including the step of attaching electrical
2 pads and electrical leads to the surface of said laminated layers.

1 55. The method of claim 49 in which said machining includes raster scanning
2 to define said features.

1 56. The method of claim 55 further including the step of controlling the depth
2 of said features by modifying said raster path.

1 57. The method of claim 46 further including the step of removing residual
2 carbon and cleaning said substrate layers.

1 58. The method of claim 46 further including the step of tacking the layers.

1 59. The method of claim 46 wherein said machining includes depositing and
2 patterning thin films of material on said substrate layer to form said electronic
3 components.

1 60. The method of claim 59 in which said material is chosen from the group
2 consisting of titanium, chrome, gold, platinum, tungsten, copper and nickel.

1 61. The method of claim 59 in which said material is plated with a material
2 including copper.

1 62. The method of claim 60 further including the step of depositing a thin film
2 of said material on said substrate layer to form an electric heater.

1 63. The method of claim 62 further including the step of depositing a thin film
2 of said material on said substrate layer to form an electric cooling device.

1 64. The method of claim 46 in which step c) further includes applying a
2 chemically functional coating to said substrate.

1 65. The method of claim 64 in which said chemically functional coating is
2 chosen from the group consisting of: polymers, antibodies, human IgG or animal IgG,
3 antibody fragments, antigens, antigen fragments, peptides, aptamers, single-stranded
4 DNA (ssDNA), and biomolecules.